TechData Sheet

Naval Facilities Engineering Service Center
Port Hueneme, California 93043-4328

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High Intensity Discharge Lighting

High intensity discharge (HID) lighting was developed in the 1950s for industrial applications. Since then, technology has continued to develop and its applications have grown beyond the industrial setting. For some applications, HID lighting is an energy-saving alternative to fluorescent and incandescent lighting. This TechData Sheet provides information on the different types of HID lamps, where they are applicable, and a cursory economic feasibility analysis for retrofitting.

HID Lamps

The four most common types of HID luminaires are:

- High pressure sodium (HPS)
- Low pressure sodium (LPS)
- Mercury vapor (MV)
- Metal halide (MH)

Each have a distinct color, electrical efficiency, lumen output, and useful life. A lumen is the quantity of illumination per area or the luminous flux. With respect to footcandles:

1 lumen per square foot = 1 footcandle

Electrical efficiency, or efficacy, is defined as the lumen output of the luminaire divided by the electrical input in watts or lumens per watt.

Typical efficacy ranges are shown in Figure 1. Note that there are both standard and white HPS lamps, the white lamps have better color than standard HPS. In addition to standard MH lamps almost all manufacturers offer compact metal halides (CMH). CMH lamps vary in construction and size and some are considerably different than the standard MH.

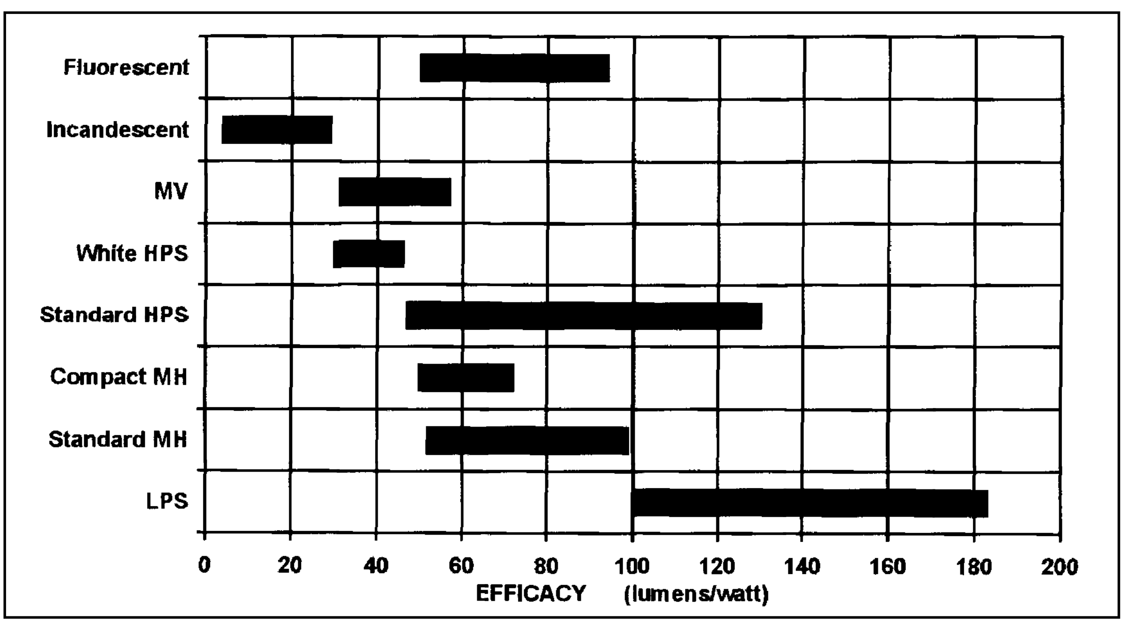

Figure 1. Lamp efficacies.

Operation and Characteristics of HID Light Sources

HIDs differ from fluorescent light sources in their construction and operation. A fluorescent lamp produces light by igniting and maintaining an electrical arc through a tube filled with gases. The most typical combination of gases is argon and krypton. There is also a small amount of mercury gas that is ionized after the arc is initiated. This ionized mercury gas emits ultra-violet radiation, which excites phosphor coatings on the inside of the tube. The phosphors glow when excited and emit light. The make up of the phosphors determines the color characteristics of the lamp.

In general, standard HIDs do not use phosphors, with the exception of color improved versions that are slightly more expensive and somewhat less efficient. HID lamps usually have two tubes -- the inner tube is the arc tube where the gases are contained under pressure. The outer tube serves primarily as a shield for the arc tube, protecting it from wind and deposits, which would impede its performance.

In contrast to the fluorescent lamp's tube, the arc tube of an HID is at high pressure. Fluorescent tubes are at less than 1 psi, while some HID arc tubes can be as high as 60 psi (as in the case of mercury vapor lamps). The arc tube's starter gas, usually argon, maintains the arc during warm up. Once the arc is started, the primary gas in the arc tube, either mercury, sodium, or a halide, begins to vaporize and glow. As more gas vaporizes more light is emitted until the lamp reaches its operating pressure and full light output.

All HIDs have a warm-up period before full light output and a minimum time before the arc can be restruck after the power has been shut off. After restrike the lamp will have to warm up again before full light output. A new idea is to attach a second lamp to the HID fixture to provide light while the HID lamp is cooling off for restrike. The most common type of secondary lamp is the quartz halogen. The secondary lamp usually does not provide the same amount of light, but is useful in cases where no light could create a hazard. Table 1 summarizes the characteristics of each lamp type.

Although retrofitting incandescent and fluorescent fixtures with HIDs can save energy, it is not always appropriate. The two biggest obstacles are restrike time and poor color. Lighting designers and manufacturers use two indices to describe a lamp's color characteristics. The color rendering index (CRI) is a measure of how much a light source will shift the color of an object from its true color. If the CRI is 100 there is no color shift; sunlight is considered to have no color shift. An incandescent source is used as the relative measuring point because it has the least color shift of common light sources. Table 1 lists CRI values for each of the lamp types.

The second index is correlated color temperature (CCT) given in degrees Kelvin. The CCT is found by heating a blackbody while observing its color characteristics at different temperatures. A light source with a CCT of 3,000°K is similar to a blackbody at that temperature. Lamps with a CCT less than 3,000 are said to be "warm" and will make red and yellow objects more distinct. CCTs over 4,000°K are said to be "cool" and generally make green and blue objects more distinct. The cooler lamps provide a "whiter" light while the warmer lamps have a pink or orange appearance. Note that the low pressure sodium lamp has a negative CRI and a low CCT. These lamps appear very yellow and most objects illuminated appear gray. They are not recommended for areas with high security. A lamp's performance should not be judged entirely on either CRI or CCT, the two values should always be considered together when choosing a lamp.

Applications for HID Lighting

The number of applications for high intensity discharge lighting is growing as new, more efficient, and less expensive lamps are developed. For instance, in a new design it is common to find compact metal halide (MH) lamps used in retail areas. The color and point source illumination characteristics of these lamps make dramatic shadows on objects, enhancing their appeal to potential customers. Compact MH lamps are also often used in entryways, reception areas, and corridors since these fixtures tend to remain on all day.

Table 1. Characteristics of HID Luminaires[1]

Lamp Type	Warm-Up (min)	Restrike (min)	kW Range	CCT (°K)	CRI	RatedLife (hours)
Fluorescent	0	0	32-212	3,800	52-83	20,000
Incandescent	0	0	25-1,500	3,000	100	2,000
MV	5	1	40-1,000	4,100	38	24,000
White HPS	5	2	35-100	2,700	80	10,000
Standard HPS	10	4	50-1,000	2,150	50	24,000
Compact MH	4	15	70-250	4,000	70	7,500
Standard MH	6	12	400-1,500	4,000	65	10,000
LPS	11	1	18-180	1,800	-44[2]	18,000

[1]All values are averages based on manufacturer's information.
[2]LPS lamps are a monochromatic light source.

Another common use of HID lighting is for building exterior lighting. Low pressure sodium (LPS) is often used when security allows. To make these successful retrofits, however, takes careful design since their economic viability depends on replacing the existing fixtures with fewer, more efficient fixtures. Each retrofit must be carefully designed to realize full savings.

General conditions where high intensity discharge lighting systems are usually appropriate as a retrofit are:

- Areas with ceilings over 15 feet
- Incandescents over 150 watts are used
- Lights stay on for long periods of time without cycling off

There are exceptions to these, of course. Display and exterior lighting, for instance, does not necessarily have to meet the 15-foot requirement. The conditions above are the most common places to find a good retrofit.

It should be noted that HID systems in general do not work well with dimmers. Efficacy drops off sharply when using conventional dimming equipment. Recently, a few manufacturers have offered two-stage systems that have a ballast that can provide half of full light output at a lower electrical load. While the efficacy is maintained at the half load setting, the systems tend to be expensive and are difficult to justify for a retrofit.

Economics of Retrofitting

Mercury vapor lighting is one of the least efficient HID light sources. Since it has long life and excellent color, it is also one of the most common. In cases where some color quality can be sacrificed, retrofitting to HPS can save a considerable amount of energy. Figure 2 shows the payback for converting to HPS from MV at different energy and demand charges. Figure 2 was made using the following assumptions.

- 90, 400-watt MV (23,000 lumens) will be replaced by 45, 400-watt HPS (50,000 lumens)
- 400-watt MV lamps have the same 24,000 hour life as HPS
- Installed cost of each new fixture is $265
- Operational hours per year is 2,500
- The utility bills for demand was 5 months per year

MV lighting can also be replaced with MH, the payback, however, is roughly twice that of the HPS retrofit shown above. The advantage is the MH provides equal, if not superior, color rendering characteristics to MV.

Figure 3 shows the payback for replacing 120-watt incandescent parabolic aluminized reflector (PAR) lamps with 100-watt compact metal halide fixtures at different energy and demand charges. The PAR lamp is a common type of incandescent used in display lighting. Figure 3 was made using the following assumptions:

- 100, 120-watt incandescent PAR fixtures were replaced by 24, 100-watt CMH fixtures
- Installed cost of each new fixture is $225
- Incandescent lamps cost $3.37 each, have a 200-hour life, and a 1,420-lumen output
- 100-watt CMH lamps cost $22.49 each, ballasts cost $100, the lamps have a 10,000-hour life and a 6,000-lumen output
- The utility bills for demand was 5 months per year

If Figures 2 and 3 show that you have a less than 10-year payback on these retrofits, contact your local EFD about submitting a project. Keep in mind that there are many other feasible retrofits, these two are perhaps the most common. The information in this guide should help to identify other HID projects.

Additional Information

Some lighting manufacturers provide excellent full color applications guides for HID lighting. Phillips, for instance will send you their “Industrial Lighting Application Guide” for about $5.00. You can contact Phillips at (908) 563-3000.

If you have any questions regarding HID lighting, contact:

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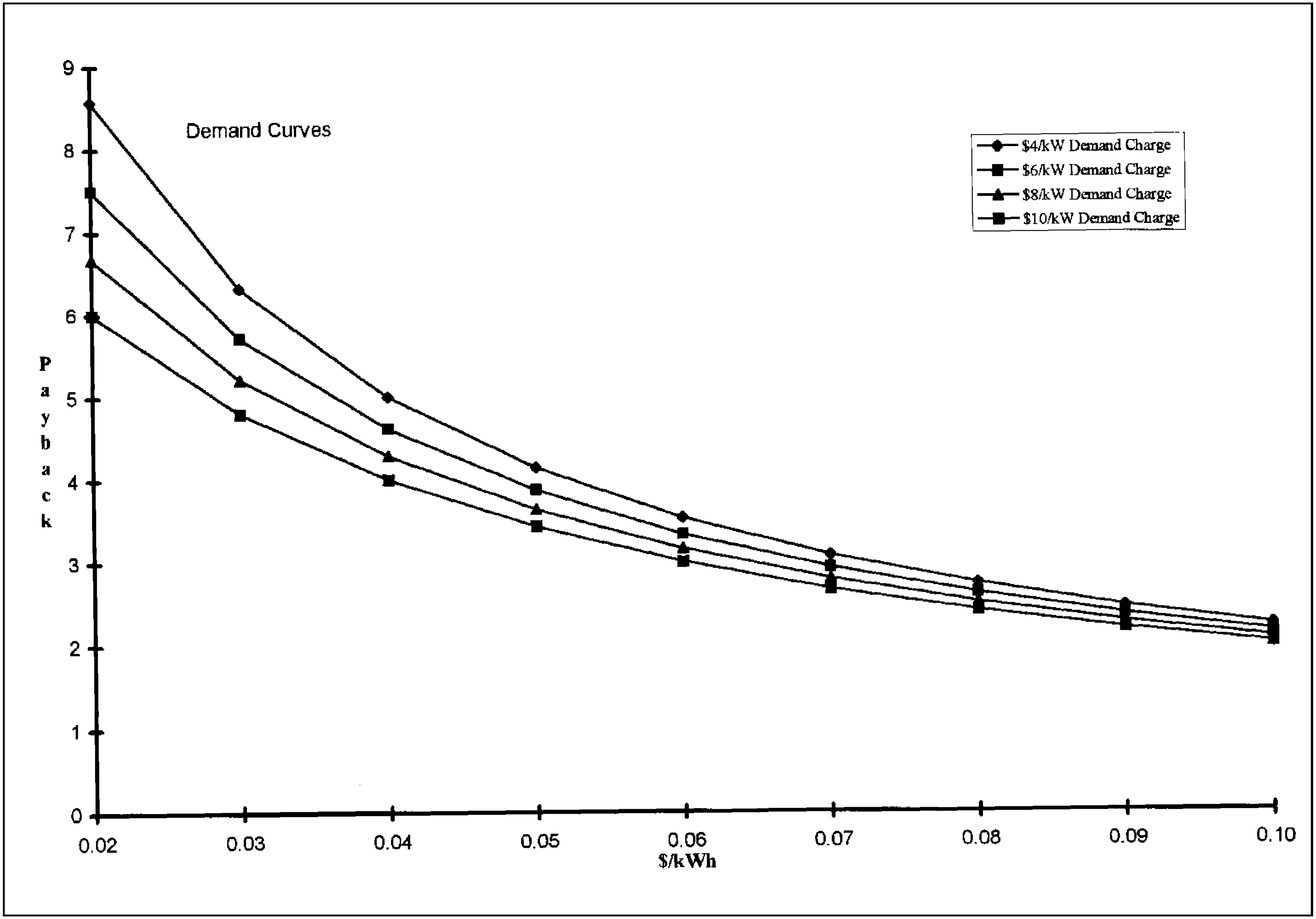
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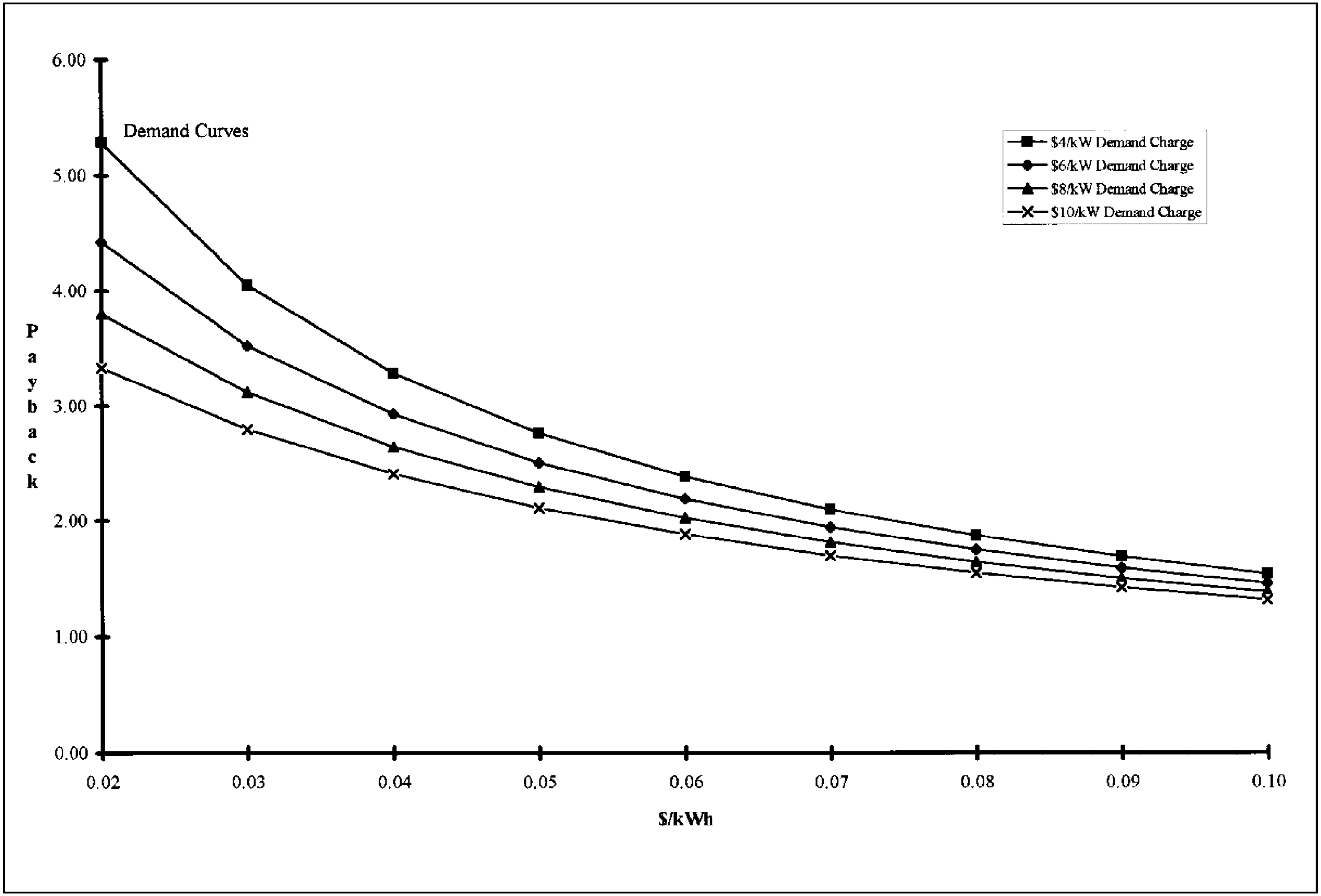
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